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Agricultural Research

Cholesterol-Reducing Goodies, Thanks to Oatrim

Food Product Research: An Investment in Health

We all know that preventive health measures save money—and one of the most important preventive measures is to eat healthier foods.

But we don't all act in accordance with what we know. When it comes to food, Americans are notorious for enjoying too much, and the wrong kinds, of a good thing. Twelve percent of us are estimated to be clinically obese. Even many who are not obese maintain diets that are too high in calories and too low in fiber.

Two food ingredients—fluffy cellulose, patented in 1988, and Oatrim, in 1991—could benefit the health of millions. Both are recent examples of discovery and technology transfer at the National Center for Agricultural Utilization Research in Peoria, Illinois.

Many of our excess calories are consumed in flour-based baked goods such as bread and donuts. One of the discoveries, a natural, noncaloric dietary fiber, can replace up to half of the flour in baked goods, thereby lowering their total caloric content.

Prepared from agricultural byproducts such as wheat straw or cornstalks, fluffy cellulose is a combination of two building blocks of plant cell walls—cellulose and hemicellulose. Its insoluble, indigestible fiber provides needed bulk in diets without affecting the flavor of bread, cookies, cakes, crackers, doughnuts, and other foods made from it.

The second discovery, Oatrim, contains fiber that has a different beneficial effect: lowering blood cholesterol. Made from oat flour and bran, Oatrim has only one-ninth of the calories found in the fats it can replace in food formulations.

Most Americans 2 years old and up consume far more fat than the 30 percent of calories recommended in the dietary guidelines issued jointly by USDA and the Department of Health and Human Services.

It seems fitting that fat substitutes could come to play an important role in school lunch programs. And older Americans might enjoy fuller lives less burdened by sickness, suffering, and medical bills by consuming these healthful foods.

In short, Oatrim could be of significant benefit to a nation considering universal health care coverage. (A review of Oatrim from a nutrition and health perspective begins on page 4.)

Oatrim evolved from a chain of crop utilization studies. Chemist George E. Inglett originally hoped to use enzymes to convert starch into gums similar to imported gums whose availability and price fluctuate widely. While working in private industry, he had researched enzymes for processing cornstarch into sweeteners.

The transfer of Oatrim technology began as Inglett chaired a symposium on beta glucan—the principal soluble fiber in oats and barley—and held a press conference at the April 1990 meeting of the American Chemical Society. To cope with a huge volume of subsequent requests for more information, Inglett invited food company representatives and news media to a second press conference in Peoria the following month.

How was interest in Oatrim translated into commercialization? It wasn't just a case of "build a better mousetrap and the world will beat a path to your door." There had to also be an evaluation of the invention's significance and its adaptability to fill a niche in the marketplace. And, Inglett maintains, a solid commitment to carrying forth technology transfer at every level within ARS and cooperating organizations. It was the continuing dialogue between both people and organizations that resulted in a reservoir of mutual respect and trust.

Fluffy cellulose inventor J. Michael Gould, who is now with the Biotechnology Research and Development Corp. in Peoria, and George Inglett have each received the R&D 100 Award and the Federal Laboratory Consortium's Award for Excellence in Technology Transfer.

Let's hope that USDA's scientists will continue to further the nation's efforts toward cost-effective preventive health care by means of improved foods.

Richard L. Dunkle
Midwest Area Director
Agricultural Research Service

Agricultural Research

Cover: Brownies, cookies, and muffins baked with Oatrim instead of the usual cooking fat look and taste as good as those made "the old-fashioned way." But these reduced-calorie baked products are better for you in more ways than one. Photo by Scott Bauer. (K5344-20)

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Two Thumbs Up for Oatrim

Human study shows a double benefit from this new fat substitute.

SCOTT BAUER

Baking with Oatrim: Before human nutrition studies could begin, chemist Kay Behall developed the Oatrim recipes. (K5343-2)

The diet got mixed reviews: "I had a hard time eating the spaghetti sauce, but I could eat the brownies or muffins with every meal," says Pat Howard, one of 24 volunteers in the first human study of Oatrim.

But this new ARS-developed fat replacer with an extra cholesterol-lowering punch in the form of beta glucan got two thumbs up in its research debut.

Not only did the volunteers have a substantial drop in the artery-clogging LDL cholesterol without a decrease in beneficial HDL cholesterol; their glucose tolerance—ability to process sugar from a meal—improved significantly also.

The volunteers were selected for the study on the basis of elevated cholesterol levels, says Judith Hallfrisch, who heads carbohydrate research at the Beltsville (Maryland) Human Nutrition Research Center and co-led the study with nutritionist Kay Behall. It turned out that most of the volunteers also had elevated insulin levels, which means they were less efficient at metabolizing dietary sugar and at greater risk of developing diabetes.

Oatrim reduced the volunteers' insulin levels 11 to 24 percent, depending on the level of beta glucan in the fat replacer. And glucagon, a hormone that has the opposite effect of insulin and moves glucose from body cells into the blood, dropped a significant 16 to 36 percent. As a result of these hormone changes, the volunteers' blood glucose levels were 7 to 12 percent lower after eating Oatrim than they were before.

But the biggest surprise of the study may be Oatrim's main payoff: Most of the volunteers lost weight during the study, despite increases in their calories. As a group, they lost an average 4.5 pounds, says biologist Daniel Scholfield who worked with Hallfrisch and Behall.

Nutrition researchers and dietitians

carefully plan calorie intakes of each volunteer in human studies to prevent any changes in weight. Otherwise, it's not clear whether the results are due to the variable being tested or to a weight gain or loss. So the Beltsville dietitians were understandably disturbed that they could not maintain the volunteers' weight, even after increasing calories.

Since the study began in early spring, Hallfrisch suspects some of the weight loss was due to an increase in the volunteers' activity as the days got longer. But Oatrim was a big factor.

"I think this is the value of Oatrim," she says. People can lower their cholesterol by making dietary changes, such as eating less fat and cholesterol or more beans, grains, and other high-fiber foods. "Oatrim could replace fat and lower overall calorie intake without a loss of satiety. Nobody in the test complained about being hungry," she adds. "They were very full!"

The reason for this fullness lies in the unique property of Oatrim, says its developer, ARS chemist George E. Inglett at the National Center for Agricultural Utilization Research in Peoria, Illinois. The combination of beta glucan—a soluble fiber credited with the cholesterol-lowering property of oats—and amylodextrin makes Oatrim absorb water like a sponge and turn into a gel. Unlike other fat replacers, "it swells tremendously."

In the Beltsville study, researchers used two compositions of Oatrim—1 percent and 10 percent beta glucan. "The 10 percent turns into something like silly putty when mixed with water," Scholfield says. "The 1 percent is more fluid."

Hallfrisch and Behall wanted to test two levels of beta glucan on the volunteers to see if the amount of soluble fiber was important in lowering cholesterol levels. So half of the 24 volunteers got Oatrim with 1 percent beta glucan for 5 weeks of the study, and the other half got 10 percent beta glucan. Then each group switched to the other composition for 5 more weeks.

As it turned out, cholesterol levels dropped about the same on both compositions as did the volunteers' weight, says Behall. However, "there was a trend for 10 percent beta glucan to improve glucose tolerance more than the 1 percent beta glucan."

She says there are several theories on how soluble fibers such as beta glucan reduce cholesterol, but research has yet to substantiate any of them.

Neither Oatrim composition reduced blood triglyceride (fat) levels. But levels dropped significantly during the first week of the study when all volunteers were put on the same diet to start them out on equal footing before they got Oatrim. The equilibration diet, as it is called, contained 35 percent of calories as fat and was probably healthier than the diet volunteers normally ate, Behall notes.

The biggest surprise of the study may be Oatrim's main payoff: Most of the volunteers lost weight during the study, despite increases in their calories. As a group, they lost an average 4.5 pounds.

After the first week, each volunteer got 50 grams—about one-half cup—of Oatrim powder in various foods throughout the day. The researchers modified standard recipes, using Oatrim to replace from one-quarter of the fat in such foods as muffins and cookies to all of the fat in pancakes and waffles.

This way they reduced the volunteers' daily fat intake to the recommended 30 percent of total calories. Oatrim supplied another 10 percent of calories, while other carbohydrates—sugars and starches—accounted for 45 percent. And protein made up the remaining 15 percent.

Volunteer Mervin Parker, who says he usually "eats on the go" and consumes a lot of fast food, is anxious to get into another study. "It's healthy food; they cut out the things you shouldn't have. And it's convenient to have your meals prepared for you."

The Beltsville dietitians successfully hid the white powder in muffins, cakes, waffles, cookies, brownies, and meatloaf. But they couldn't disguise it so well in the Jell-O, yogurt, gravy, soups, spaghetti sauce, and fruit juices.

"Overall, the food was real good," says volunteer Ray Mock. "Just in some of the items, there was a difference in consistency." For instance, the powder didn't always dissolve completely in some of the juices, he notes. "You had a little texture with your orange juice . . . more than just pulp."

Mock says he could "most definitely" tell the difference between 10 percent and 1 percent Oatrim. "Some of the foods with the higher percentage were kind of gummy."

That's no surprise because soluble fibers are gums.

Also, several of the volunteers experienced gastrointestinal discomfort on the higher fiber intake. But most adjusted after a while, Hallfrisch says. In fact, she sees Oatrim as a potential fiber source for the elderly. "It may be easier to digest than raw fruits and vegetables."

Having Your Cake—Eating It Too

Behall says Oatrim is easier to incorporate into food items than any of the other gums she has worked with—and she has tried lots of them. Oatrim doesn't decrease the baked volume of the product like other gums, she notes. "We can have products that are comparable in looks and appearance, taste and texture to what we're used to, but with less fat. Plus, you get a bonus from the thickening quality of Oatrim. It maintains the texture."

According to Inglett, its gelling property "gives a more creamy, fatlike texture to foods than do other starch-based fat substitutes on the market. And it does more for your health."

One gram of Oatrim gel—the form used most often in commercial foods—contributes only one calorie, compared to nine calories per gram of fat, he says. The gel behaves like shortening: It's solid at room and body temperatures but turns liquid at cooking temperatures.

Beta glucan, Inglett explains, is the principal fiber in oats and barley. It's a very long chain of glucose sugars linked together in a beta configuration rather than the alpha configuration of starch.

Since we don't produce enzymes to cut these beta links, the glucose units are not absorbed through the small intestine as is the case with starch. As a result, beta glucan provides few if any calories. The calories in Oatrim come, rather, from amylodextrin—shortened fragments of starch.

SCOTT BAUER

Monitoring hormones: An automated gamma counter speeds analysis by nutritionist Judith Hallfrisch and biologist Daniel Scholfield of hormone levels in blood samples drawn from Oatrim study volunteers. (K5342-20)

Inglett first announced development of Oatrim in April 1990. It is now being made and marketed under exclusive licenses by two partnerships in the food industry. One partnership is between Quaker Oats and France's Rhone-Poulenc. The other is a joint venture between the U.S. agribusiness giant, ConAgra, and A.E. Staley of Great Britain, called Mountain Lake Manufacturing.

SCOTT BAUER

Oatrimed foods: Dietitian Priscilla Steele discusses various food items containing the odorless, tasteless Oatrim powder with volunteer Pat Howard. (K5341-3)

Several products containing Oatrim are already on the market, with more on the way, says Inglett. He estimates that some 40 products are under development at the pilot level. "But they'll have many hurdles to cross to meet company standards before there's a product in the marketplace."

Steve Grisamore, general manager for Mountain Lake Manufacturing, says: "If the finished product doesn't taste like the full-fat product, people won't buy it. In general, people won't buy a product simply because it has beta glucan."

Grisamore says Mountain Lake is selling Oatrim under the trade name of TrimChoice. It is in several of ConAgra's Healthy Choice line of products—hot dogs, bologna, cheese, and 96-percent-fat-free ground beef. Smaller companies are using the fat-replacer in

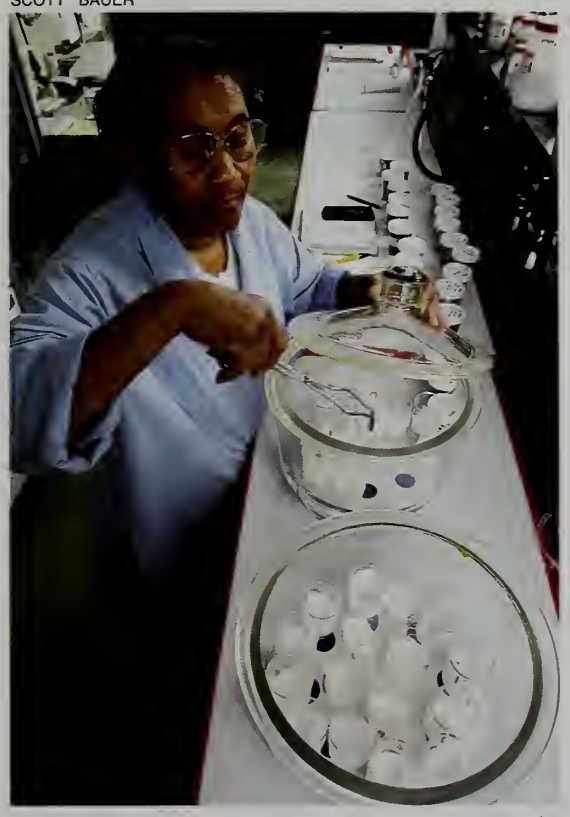
baked products, such as muffins and cookies, and in chocolate candy.

The Quaker Oats/Rhone-Poulenc partnership expected to have two grain-based products on the market in the last quarter of 1993, according to John Kacher, with several more products due out in 1994. Kacher is business director of low-fat systems for Rhone-Poulenc, which does most of the marketing of Oatrim. Some of his customers are already marketing a no-fat pancake mix; a very low-fat, high-fiber nutrition bar; and a meatless frankfurter containing Oatrim, he said.

Kacher says Oatrim compares favorably with any currently FDA-approved fat replacer. "It's a crowded field—there are a lot of products out there." Commercially speaking, he echoes Grisamore. "There's not much interest in beta glucan, the fiber part. People will buy the product because it replaces fat." He says certain fat replacers should work better for certain products.

Grisamore agrees. He projects that the market will grow quickly once food companies learn how to make products that have qualities similar to their full-fat counterparts. He says fat-free products are improving since they were first introduced in 1990, because the companies are realizing that it takes more than a single ingredient to replace fat. "I'm confident that people in the industry have identified that we need a systems approach—a combination of several ingredients."

SCOTT BAUER



Fiber quotient: To determine the amount of fiber in foods, samples are heated and filtered in crucibles such as these being inspected by biological lab technician Willa Mae Clark. (K5342-11)

Unfortunately for volunteer Vivian Shimanuki, whose cholesterol level "dropped dramatically" during the study, neither partnership sells the white powder used in the Beltsville study to consumers. "If I could find this kind of Oatrim out there, I would definitely add it to all my foods," she says emphatically.

Shortly after the study, Shimanuki had her cholesterol tested, and "it had gone back up with my normal type of eating," she says. "I know now that it can be controlled with the selection of food and enhanced, I'm sure, with Oatrim."—By **Judy McBride,** ARS.

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Award-Winning Fat Replacer

Oatrim was named one of the 100 most significant new technologies of 1993 by Research and Development Magazine. The R&D 100 award recipients are selected by a panel of scientific experts and the magazine's editors.

In this 31st year of the magazine-sponsored international competition among corporations, government laboratories, private research institutes, and universities, Oatrim joins the ranks of previous winners. Well-known products that have received the award and gone on to become a part of everyday life include polacolor film, the electronic video recorder, antilock brakes, the automated bank teller machine, and halogen lamps.

The fat substitutes industry is projected to gross multi-billion-dollar sales by the year 2000. Oatrim's successful entry into the industry involved extensive communications between the inventor, ARS chemist George E. Inglett, and the companies that licensed the technology.

Last year, when Inglett was one of 30 researchers nationwide to receive the Federal Laboratory Consortium's Award for Excellence in Technology Transfer, Richard L. Dunkle, then director of ARS' National Center for Agricultural Utilization Research said, "In only 2 years, the results of Dr. Inglett's work have proceeded at a remarkable pace, from laboratory research and patenting of the Oatrim process to commercialization."

Since 1991, Inglett has also received the ARS Technology Transfer Award, NCAUR Scientist of the Year Award, and the USDA Distinguished Service Award, along with the Food Processing (magazine) Award, the Chairman's Award from the Chicago Section of the Institute of Food Technologists, and the Macy Award from the Institute's Minnesota Section.—**Ben Hardin,**

KEITH WELLER

Genetic Fingerprinting Helps Sort Out Look-Alikes

One of the main purposes of genetic resources collections is to preserve genetic diversity, as an insurance policy against future disease or pest threats.

Collector's item: Curator Jim McFerson monitors growth in a seed-production plot of cauliflower, one of the many cole crop species maintained in the Geneva, New York, *Brassica* collection. (K5331-14)

If Steve Kresovich were judging an Elvis look-alike contest, he probably wouldn't pay much attention to the contestants' clothes, hair, or jewelry—or even to their voices.

He'd ask for a genetic fingerprint.

No need to guess anymore. Not with biotechnology techniques that scientists can use to establish "fingerprints" from genetic material called DNA, the stuff of which living things are made.

Kresovich and his Agricultural Research Service colleagues are using these techniques to fingerprint plant genetic material called germplasm to determine how one plant is genetically different from another.

"Because so many plants look the same, you really can't be certain about their genetic diversity unless you have a way to identify their genes," says Kresovich. "As with the Elvis look-alike contestants, it's hard to tell them apart visuallly. But if you could compare their genes, there wouldn't be any doubt that they were different."

DNA fingerprints, scientists say, will one day be as common as the ink thumbprint. Criminal suspects are now being convicted based on a genetic fingerprint from their semen or blood—even from a piece of hair or a fingernail—that matches one found on a victim. On the other hand, wrongly convicted criminals are being released from prison, freed by a genetic fingerprint that didn't match their own.

Researchers today are also mapping the human genome—discovering genes linked to certain key diseases such as cystic fibrosis, so that they can be detected and treated sooner. And they're identifying valuable plant genes that could mean enhanced resistance to diseases, insects, and other threats to the food supply.

For the last several years, Kresovich and colleagues have been assessing the genetic diversity of germplasm collections held by the Plant Genetic Resources Unit at Geneva, New York, by identifying molecular markers.

At the New York State Agricultural Experiment Station at Cornell University's Geneva campus, he oversaw the unit that maintains germplasm collections of apples, grapes, broccoli, cauliflower, clover, tomatoes, celery, onions, and other crop plants. In July, he became head of the ARS Plant Genetic Resources Conservation Unit at Griffin, Georgia, where researchers are conducting similar work on other germplasm. The Griffin collections include forage grasses and legumes, peanuts, peppers, sorghum, sweetpotatoes, and watermelons, among others.

KEITH WELLER

Apples galore: More than 3,000 varieties are maintained at Geneva, New York. The largest shown here is a Wolf River from Wisconsin; the tiny ones come from the Orient. (K5339-15)

The genetic information of plants and other living organisms is stored in DNA. Except for clones, no two plants are likely to have the same DNA sequences. The differences in genetic composition are what Kresovich and other geneticists call genetic diversity. This diversity is contained in germplasm, the living tissue from which new plants can be grown. Germplasm can be cuttings, seeds, or even cells for culturing into a new plant.

For a genetic resources collection to be valuable, it should have genetic diversity. Let's say a new disease threatened the winter tomato crop in California or Florida, prompting plant breeders to look for germplasm with genetic resistance to the disease.

If a tomato germplasm collection contained 100 samples—what curators call accessions—but 75 of them had virtually the same genetic makeup, chances are slim it would have the right genes. But if 75 of those 100 accessions had widely divergent genetic compositions, a breeder would be more likely to find one with a gene to thwart the disease threat.

One of the main purposes of genetic resources collections is to preserve genetic diversity, as an insurance policy against future threats. "It relates to the story of Noah and the ark," Kresovich says. "If you've got 100 varieties of tomatoes and you can only save a few from the flood, which do you pick? How do you know you're saving the most useful ones?"

To make that decision, it would help to know something about each plant's DNA and the genes that are part of that genetic material. Today, it's not a flood of water threatening plants, but waves of development that threaten wild plants that contain the genetic diversity breeders seek.

Traditionally, curators have gained insight into a plant's genetic makeup by examining its overall form—leaves and fruit, for example—and other factors, such as how it responds to drought, disease, or insects. But looks can be deceiving.

"Curators need to know as much as possible about the genetic makeup and structure of their collections, especially where the strengths and weaknesses are," he says. "That's the data we're beginning to provide to them."

Geneva houses the national germplasm collection for vegetables in the genus *Brassica*, which includes cabbage, kale, broccoli, cauliflower, and other vegetables that are valuable dietary sources of beta carotene, vitamin C, calcium, phosphorus, and other nutrients. There are 33 species and 2,000 accessions of *Brassica* at Geneva.

Amy Szewc-McFadden has begun to find markers in an oilseed rape cultivar called Jet Neuf, which was chosen to represent the *Brassica* genus. The markers she's using are called microsatellites.

"Basically they're patterns of DNA that repeat themselves over and over again," she says. "We will use these markers to relate different plants within *Brassica*. Eventually we'll be able to tie these markers to certain traits, such as disease resistance, that curators want in their collections."

Researcher Sharon Bliek has begun similar preliminary work using Golden Delicious apple, in search of microsatellites that will provide genetic information about apples in general.

Apples are one of the biggest collections at Geneva, with about 3,500 accessions, including about 2,000 of the domestic apple, *Malus x domestica*. But curator Philip Forsline says genetic studies have shown that the apple collection needs greater genetic diversity—underscoring the need for exploration for wild varieties.

Forsline and several colleagues took such an exploration trip in September to the mountainous regions of Soviet Central Asia, thought to be the center of origin for the domestic apple.

They went to Kazakhstan and Kyrgyzstan, now independent republics of the former Soviet Union located along the trade routes that ancient travelers followed to bring silk from China. On the way, they also brought apples that were growing on wild trees in the mountains. Apple trees still growing on those hillsides may contain genes for cold and drought tolerance, disease and insect resistance, and other traits that would bolster the Geneva collection.

KEITH WELLER

By the book: To distinguish between *Brassica* accessions, molecular biologist Amy Szewc-McFadden searches genomic libraries for repeating patterns of DNA called microsatellites. (K5335-1)

"Genetic fingerprinting technology has helped us by giving us a more complete picture of the diversity in our collection and will assist with diversity studies of the wild apples we collected on the trip," Forsline says. "Because the trees and fruit look so similar, the only way you can determine their diversity is by examining their genetic makeup."

Once genetic diversity is identified, it becomes a matter of analyzing it to see what differences matter, says Warren Lamboy, who stores and analyzes the genetic data on a computer system. "For example, an apple that has bright red color, or resistance to apple scab disease—those genetic indicators are important."

Lamboy notes that much of the key genetic diversity is found in old varieties that have been farmed but haven't been bred into commercial cultivars. In a study of 14 types of *Brassica*—including cabbage, broccoli, cauliflower, and kale—the researchers found that there is very little genetic diversity in commercial cultivars.

"It's important to know that, because we want to maximize the diversity in what we keep in our collections," Lamboy says.

There's also the matter of economics, says Jim McFerson, the *Brassicas* curator who now heads the Plant Genetic Resources Unit. He points to

the example of Golden Acre, an early-maturing cabbage introduced into the United States around 1920. McFerson collected about 20 Golden Acre accessions from around the world and gave 14 of them to Kresovich and Win Phippen, a Cornell graduate student working for ARS at Geneva.

Their task: to establish and compare genetic markers in the Golden Acre plants—which all look virtually identical. "We've found that there is very little genetic diversity among them, based on DNA markers we've compared so far," Phippen says.

For a curator, that's important to know because it may affect which plants are are permanently maintained in a collection.

"It costs about $1,000 or more to regenerate seed for a given accession," McFerson estimates, "because of the carefully controlled pollination techniques that we must use. But if we've got 14 accessions that are essentially the same, it may not be necessary to regenerate all of them."

The resources and time taken to regenerate those plants could be used to do the same thing with other plants that have different, perhaps valuable genes. "The real issue for curators is how can we assemble the most genetic diversity with the least cost? Now the genetic identification technology will allow us to be more precise about each of the accessions that we keep."

Other cases where genetic identification has helped:

• *Vetiver grass.* This perennial, native to India, has been recommended for planting around the world to prevent soil erosion. The World Bank and U.S. Agency for International Development have been trying to determine the best varieties to recommend for planting, based on climate and other conditions. The scientists found that some varieties thought to be different were genetically identical, while others thought to be identical were actually different.

• *Helicobacter pylori.* Even bacterial look-alikes are being sorted out. While on a 1991-92 research fellowship at Washington University in St. Louis, Kresovich worked with university scientist Douglas Berg and others on a project to study genetic diversity among 64 isolates of this bacterium, now thought to be a cause of cancer, ulcers, and other gastric ailments.

The *H. pylori* strains were taken from veterans at Huntington, West Virginia, hospitals. Most of the patients had been diagnosed with chronic gastritis. "It looks like the strains that are the biggest problem are of Asian origin—and the veterans who have them could have acquired them in Vietnam," Kresovich said. "Knowing the genetic diversity of the organism will be helpful in efforts to develop a vaccine against it."

Kresovich notes that all living organisms are defined largely by their DNA, whether they're bacteria, plants, or people. Along those lines, he's working with researchers at the Federal Bureau of Investigation's Forensic Research Laboratory at Quantico, Virginia, and with the Centers for Disease Control in Atlanta, Georgia. The FBI uses genetic fingerprinting to identify criminal suspects, while the CDC uses it to identify organisms that cause disease.

"Primarily, we're exchanging information to improve our fingerprinting methods," he says. "The techniques and goals are the same—whether it's a plant, a person, or a bacterium—to determine differences and similarities using DNA."

"The more you know about the germplasm, the better off you're going to be," Kresovich adds. "There is potentially a lot of redundancy in these collections. Each accession takes up space. Each one that's like another fills a spot on the ark that could have been used by a more valuable accession."—By **Sean Adams,** ARS.

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KEITH WELLER

On the grapevine: Horticulturist Philip Forsline, curator of the apple and grape collections, examines hybrid grapes being developed in a USDA breeding program. (K5338-9)

Exotic Lettuces Enliven Tom

Showy colors, bizarre shapes, or surprising textures of exotic lettuces may brighten salads of the future. In California's Salinas Valley, where much of America's lettuce is produced, ARS researcher Edward Ryder and colleague William Waycott, now with PetoSeed Co., scrutinize an exceptional array of unique lettuces. Seed stored in ARS' permanent collection at Salinas yielded the distinctive test-garden. The gene bank houses seed of more than 2,000 lettuce types and likely represents some 6,000 years of lettuce-breeding history.

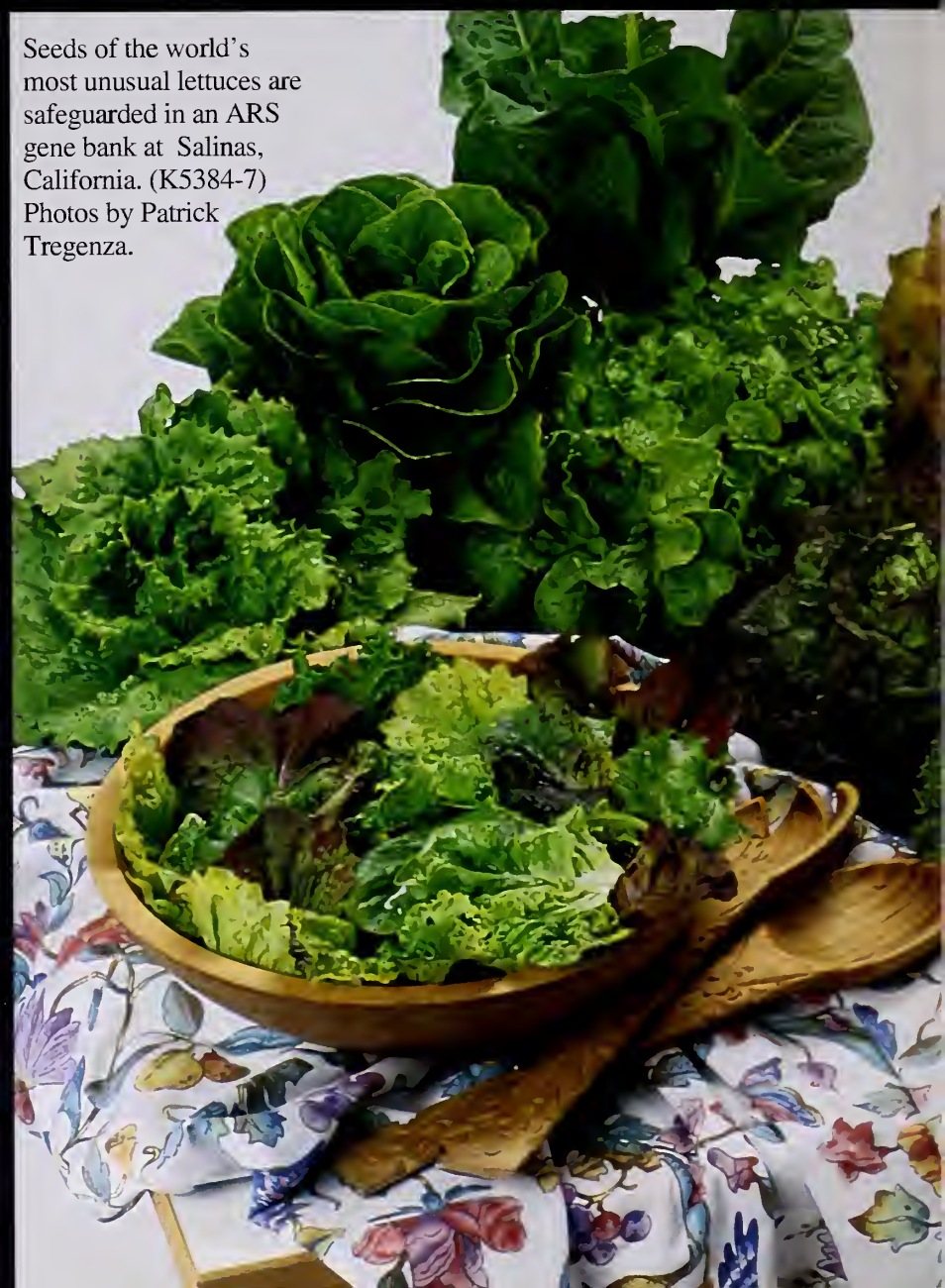
Through conventional means or perhaps bioengineering, traits like the warm gold of a Hungarian lettuce or the intense crimson of a Spanish variety, for example, might be bred into familiar iceberg, butterhead, or loose-leaf lettuces grown in the United States today, giving salads a delightful new look.—**Marcia Wood,** ARS.

Frilly "pompom" lettuce. (K5384-4)

Wild edible lettuces. (K5384-3)

Crimson-pigmented type. (K5384-5)

Glossy "nonclosing" romaine. (K5384-6)



Seeds of the world's most unusual lettuces are safeguarded in an ARS gene bank at Salinas, California. (K5384-7) Photos by Patrick Tregenza.

rrow's Salads

Lettuce breeders Ed Ryder (left) and Bill Waycott. (K5384-1)

Unique lettuces offer unfamiliar shapes, colors. (K5384-2)

Great-Tasting Peanuts? Try Hairy!

Plant breeders' attention has recently turned to the hairy, or hirsuta, peanut with its densely haired stems and leaves—a defense that could deter insect pests from feeding and laying eggs. And the hirsuta peanut is believed to tolerate heat and drought better than other peanuts.

But it was the reports of superior flavor that really sparked interest in using hairy peanuts to breed new, better flavored types for U.S. consumers, says David E. Williams, a plant explorer with the ARS National Germplasm Resources Laboratory in Beltsville, Maryland.

Williams specializes in ethnobotany, a branch of botany that deals with the relationship between human cultures and the plants in their environment.

Peanut lovers worldwide may someday thank Williams for a recent trip he took to the central highland states of Puebla and Guanajuato, Mexico. There, he and a Mexican collaborator, professor Samuel Sanchez Dominguez of the Agricultural University of Chapingo, collected 25 accessions of peanut varieties that have been cultivated and selected over many years by local farmers.

A world expert, Williams had known for some time that there were uncollected hairy peanuts in Mexico.

"Twelve of the peanut accessions collected were of the hirsuta variety, sometimes called Peruvian Runner," he says. "They're much tastier than most peanuts now grown in the United States."

They also have a very distinctive pod, rough textured and deeply indented, with sharp outstanding veins. Pods are humpbacked, with a beak at one end, and they can contain up to five dark-purple seeds.

Arachis hypogaea ssp. *hypogaea* var. *hirsuta* is one of the earliest cultivars of domesticated peanuts known. Hairy peanuts have been found in 4,000-year-old tombs in Peru, near the peanut's center of origin in South America, says ethnobotanist Williams.

Today, *hirsuta* peanuts are once again regarded as a valuable—though scarce—commodity. While there are four recognized botanical varieties of cultivated peanuts, Williams notes that hairy peanuts are the most severely underrepresented in international germplasm collections.

"Only five accessions are identified as *hirsuta* peanuts in the U.S. National Plant Germplasm Collection, which includes almost 8,000 peanuts," he says. "These Mexican accessions will almost triple the number of this type in the collection."

PHOTO COURTESY OF DAVID WILLIAMS

Still delicious: Peanuts from ancient forebears are for sale today in Cholula, Mexico.

According to Williams, *hirsuta* peanuts have been used very little in U.S. breeding programs because of their long, 6-month growing season. So one of the main reasons for his trip to Mexico was to locate earlier maturing specimens that could be used by North American breeders.

His other objectives: To gather information about where hairy peanuts can be found, special farming techniques used to grow them, local uses and market value, and how best to conserve peanut genetic resources in the places where they are growing.

Williams believes that local farmers play an important role in preserving rare crop varieties.

"In Puebla, we were surprised to find previously unreported varieties of hairy peanuts that the natives roast and boil for local sale and consumption. But these unique varieties are gradually being displaced by higher yielding cultivars and are in real danger of becoming extinct," he says. "In Guanajuato, only a single variety of hairy peanut is still being cultivated."

Williams learned that hairy peanuts have such superior flavor, Mexicans consider them a delicacy.

"Customers are willing to pay more than a dollar a pound for them locally, where they're sold roasted, boiled, or candied," he says. "It's because of these peanuts' flavor that they've survived—despite their several agronomic disadvantages: They mature very late, must be hand-harvested, and have somewhat lower yields. To gather them, local farmers must dig through the soil with hand tools."

Flavor tests on the new hairy peanuts are under way by ARS chemists working at North Carolina State University in Raleigh.

The new accessions have been added to the National Plant Germplasm System. "They will help fill some of the gaps in the peanut genetic diversity presently available to peanut breeders. Plant breeders worldwide will have access to this germplasm to improve existing commercially grown peanuts," Williams says.—By **Hank Becker,** ARS.

David E. Williams is at the USDA-ARS National Germplasm Resources Laboratory, Beltsville Agricultural Research Center, 10300 Baltimore Ave., Beltsville, MD 20705-2350; phone (301) 504-6310, fax (301) 504-6305. ◆

SCOTT BAUER

Hot stuff!: Plant geneticist John Stommel evaluates a new crop of pungent, edible peppers grown from a cross between a hot Indian pepper and others with ornamental foliage. (K5334-14, inset K5333-8)

At a distance, the bright-green foliage liberally sprinkled with brilliant red splashes of color looks like a plant decorated for the holidays. But a closer inspection shows the miniature Christmas tree to be an ornamental pepper plant that's loaded with clusters of red, Tabasco-like peppers.

"This plant is grown from one of three ornamental pepper lines developed by USDA scientists from a diverse collection of hot Indian peppers," says John R. Stommel, plant geneticist at the ARS Vegetable Laboratory in Beltsville, Maryland. "All three breeding lines contain unique combinations of genes for leaf variegation, leaf pigmentation, and multiple fruiting."

Released as germplasm lines 90C40, 90C44, and 90C53, all bear fruit that is edible—but exceedingly pungent. Their coded names pinpoint the year final plant selections were made (1990), the "C" stands for *Capsicum annuum* L., and 40, 44, and 53 identify the individual lines.

Selected for their ornamental value, these peppers have each proven successful in commercial trials as potted plants in California and as bedding plants in Illinois and Japan.

Line 90C53 grows the largest, forming a bushy plant about 21 inches tall, with bright green leaves faintly mottled with dark purple. Peppers are borne upright and appear singly and in clusters of two or three. The deep purple peppers turn bright red in about 4 months.

The more compact germplasm line 90C44 was selected for its dark purple—nearly black—leaf color and numerous upright pepper clusters that also turn from purple to red.

Line 90C40 produces bushy, green-purple-white variegated plants that grow to about 15 inches tall. Unlike its two siblings, this line was chosen for its variegated foliage. It bears inconspicuous, pendant peppers.

Although introduced as ornamental peppers, the new germplasm also has potential for vegetable pepper breeding programs. The original parents from which the new lines were derived are potential sources of resistance to root knot nematode, bacterial wilt, and phytophthora root rot. The new lines were not selected or screened for this pest resistance, though.

Original plant crosses were made by T.H. Barksdale, who is now retired from the Beltsville Vegetable lab.

ARS plant geneticist Robert J. Griesbach of the Florist and Nursery Crops Laboratory at Beltsville worked with Stommel to develop these germplasm lines.—By **Doris Stanley**, ARS.

John R. Stommel is at the USDA-ARS Vegetable Laboratory, Beltsville, MD 20705; phone (301) 504-5583, fax (301) 504-5555.

Robert J. Griesbach is at the USDA-ARS Florist and Nursery Crops Laboratory, Beltsville, MD 20705; phone (301) 504-6574, fax (301) 504-5096. ◆

Selecting for Survival

About half of the world's grazing lands could be improved by reseeding or interseeding them with improved grasses. This would increase meat production, improve habitat for wildlife, and slow soil erosion.

But this improvement is often difficult to achieve.

Reseeding rangeland is considerably more complex than simply strewing seed on soil and praying for rain, say Agricultural Research Service scientists. Most desirable grasses—those that are palatable to livestock and wildlife and provide high nutrition—can be difficult to establish.

"Some seeds may readily sprout, only to die a few days later when dry weather and high temperatures arrive. Others may survive 1 or 2 years before disappearing," says plant physiologist Douglas A. Johnson at ARS' Forage and Range Research Laboratory, Logan, Utah. And some may appear to have adapted to the environment for 10 years or more before dying or being crowded out by other plants that are less desirable.

"Attaining long-term grass stand survival has been and continues to be a major objective of our range plant breeding programs," says plant geneticist Kay H. Asay. "Of various seed and seedling characteristics that we have studied over the years, two—the weight of individual seeds and the ability of seedlings to emerge from a deep planting depth—most determine the success of reseeding cool-season grasses."

Johnson and Asay have shown these two traits to be the most important in breeding lines of crested wheatgrass and Russian wildrye in the western United States.

By following these selection criteria during the past 15 years, Logan scientists and others at Mandan, North Dakota, and in Canada have been able to develop and release Hycrest crested wheatgrass and Swift, Mankota, and Bozoisky-Select Russian wildryes. These improved plants have up to 25 percent greater survival rates than their wild counterparts.

The scientists believe their findings indicate that significant improvement could be made in other cool-season range grasses if plant breeders would select for just these two factors.

Cool-season grasses such as crested wheatgrass and Russian wildrye begin growth earlier on rangeland, before warm-season grasses and most other native and introduced cool-season grasses. They provide important early-season nutrition for range livestock and wildlife. An abundant mix of grasses is desirable on ranges to supply a year-round forage supply.—By **Dennis Senft,** ARS.

Douglas A. Johnson and Kay H. Asay are at the USDA-ARS Forage and Range Research Laboratory, Utah State University, Logan, UT 84322-6300; phone (801) 750-3067, fax (801) 750-3075. ◆

Fruitful Mountain Ash

Mountain ash trees that may line sidewalks in your neighborhood produce small orange or red berries each fall. Though colorful, the berries are too bitter to eat.

But other, lesser-known types of mountain ash yield larger, tasty fruits—a feature that might boost the tree's appeal for backyard planting, says ARS curator Kim E. Hummer at Corvallis, Oregon.

One candidate for home landscaping is a *Sorbopyrus,* a mountain ash *(Sorbus)* and pear *(Pyrus)* cross. It's one of more than 60 different kinds of mountain ash from around the world that Hummer and her staff preserve at the ARS National Clonal Germplasm Repository.

The tree bears a delicious fruit that's about the size of a small peach. Portions of the fruit's speckled, pale-yellow skin are tinged with an attractive reddish blush; inside, the yellow flesh has the "sweet, mild taste of a pear," notes Hummer.

Since 1986, the Corvallis repository has been a source of the unique hybrid for breeders, nurseries, and amateur fruit growers. Among those who've requested cuttings is horticulturist Jim Gilbert of Molalla, Oregon. Gilbert says his company, Northwoods Wholesale Nursery, today sells several hundred young *Sorbopyrus* trees a year, "mostly to adventuresome customers who want to try something new."—By **Marcia Wood,** ARS.

Kim E. Hummer is at the USDA-ARS National Clonal Germplasm Repository, 33447 Peoria Road, Corvallis, OR 97333; phone (503) 750-8712, fax (503) 750-8717. ◆

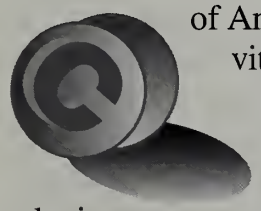
SCOTT BAUER

Pearlike: Tasty fruit of a mountain ash/ pear cross. (K5308-05)

As Vitamin Sources—Food or Supplements?

With evidence growing that higher intakes of the antioxidant vitamins C and E may help protect us against cancer and heart disease, Agricultural Research Service and National Cancer Institute (NCI) scientists collaborated to see how well food sources stack up against supplements in raising blood levels of these vitamins.

According to Gladys Block, who began the study while at NCI, about 86 percent of vitamin C in the average U.S. diet comes from fruits and vegetables. However, about 25 percent of Americans also take vitamin C supplements—alone, or in a multivitamin—according to Block, who is now at the University of California, Berkeley.



But until now, the general assumption that vitamin C from fruits, vegetables, and supplements is equally absorbed by the body had not been tested thoroughly, says Reed Mangels, who was formerly with ARS' Beltsville Human Nutrition Research Center and now does nutrition consulting. So she organized a study of 68 men to determine the relative bioavailability of vitamin C from oranges, orange juice, and broccoli—both cooked and raw.

Mangels says she compared the men's response to orange juice vs. orange segments because orange juice is a major contributor of vitamin C in the U.S. diet. Based on one nationwide survey, she notes, orange juice provides more than one-quarter of the vitamin C consumed by adults.

With the exception of raw broccoli, both the food sources and the tablet were equal at restoring plasma vitamin C levels after the men had been fed very low vitamin C diets for 1 month to deplete their levels. Raw broccoli was at least 20 percent less effective at raising plasma levels than the other foods, says Mangels.

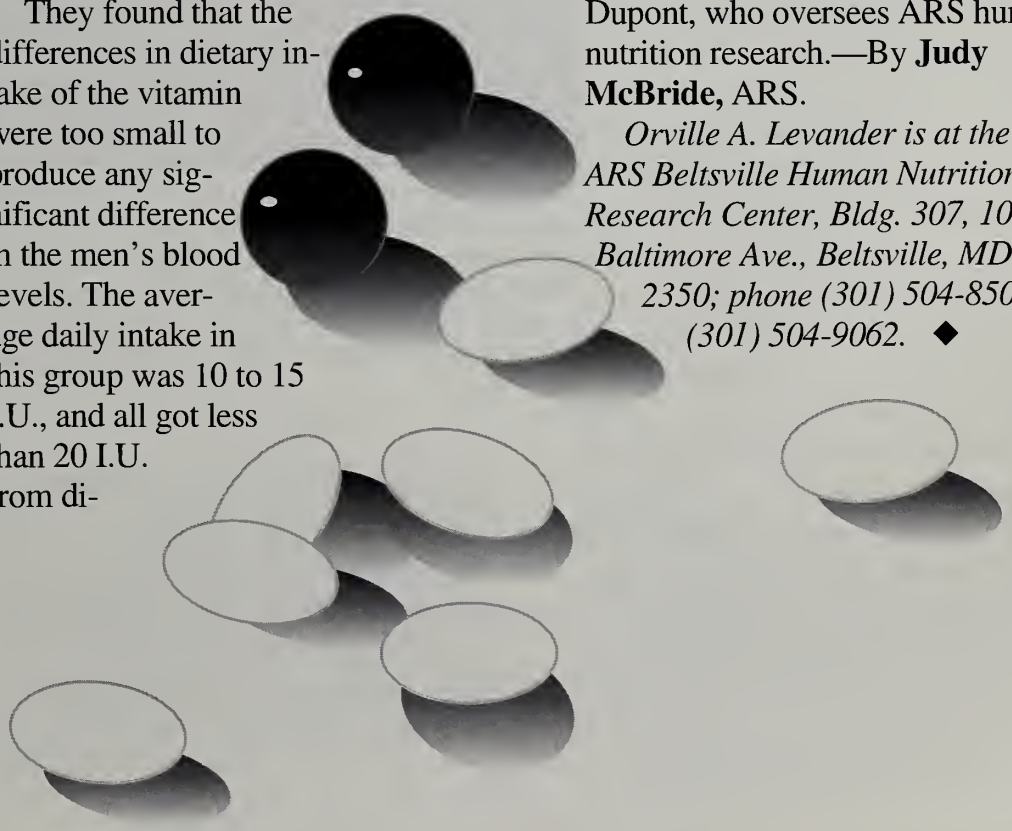
But citrus fruits and broccoli are not the only rich sources of vitamin C. Between one and two times the Recommended Dietary Allowance is contained in a cup of cooked cauliflower, kohlrabi, brussels sprouts, or edible pea pods. One green or red pepper, one kiwifruit, a cup of strawberries, or half a cantalope also provide more than the RDA. Many other fruits and vegetables also contain significant amounts.

Unlike vitamin C, it's much harder to get extra vitamin E from foods. "It's virtually impossible to get more than 25 International Units (I.U.) per day through the diet," says vitamin E expert Orville A. Levander of the Beltsville center. The RDA is 15 I.U. for men and 12 I.U. for women.

Levander says the normal average daily intake is about 10 to 15 I.U. And because vitamin E is fat soluble, the richest sources are vegetable oils and high-fat products made from them, such as margarine.

Mangels and Levander collaborated with Rashmi Sinha, Block, and others at the NCI to compare how diets and supplements contributed to plasma levels of vitamin E in 65 of the men in the study.

They found that the differences in dietary intake of the vitamin were too small to produce any significant difference in the men's blood levels. The average daily intake in this group was 10 to 15 I.U., and all got less than 20 I.U. from dietary sources. Those who took a multivitamin at least every other day got an extra 15 to 60 I.U. daily. And a third group that took daily vitamin E capsules got at least 100 I.U. above their dietary intake, says Sinha, a nutritional epidemiologist.



Compared to the group that did not take supplements regularly, plasma vitamin E levels averaged 14 percent higher in the group that took multivitamin supplements, she says. But the levels were more than twice as high in the group that took vitamin E capsules on a daily basis.

"If people want to substantially increase their plasma levels," says Sinha, "it has to be done with a vitamin E supplement." This puts the nutrient in the category of a pharmaceutical, such as aspirin when it's used to reduce risk of heart attack from blood clotting.

The problem is that science hasn't yet established the levels of vitamin E, either in the diet or blood plasma, that may help prevent heart disease and certain cancers, notes Levander. But there are hundreds of other antioxidant compounds in foods that may, together with vitamin E, provide all the antioxidant protection needed, says Jacqueline Dupont, who oversees ARS human nutrition research.—By **Judy McBride,** ARS.

Orville A. Levander is at the USDA-ARS Beltsville Human Nutrition Research Center, Bldg. 307, 10300 Baltimore Ave., Beltsville, MD 20705-2350; phone (301) 504-8504, fax (301) 504-9062. ◆

Secrets of Soil Nutrient Uptake

A natural enzyme once thought to affect only plants' absorption of iron may instead be a major gatekeeper in plant uptake of copper, manganese, magnesium, and other vital nutrients from the soil.

The multipurpose enzyme—ferric-chelate reductase—was first recognized in the 1970's as a key player in plants' transformation of iron into a form plant roots could absorb.

Iron is present in soils mainly in its oxidized or ferric form. But all plants, except cereals, must transform this iron to its ferrous form to be able to absorb and use it. To accomplish this transformation, the reductase enzyme adds an electron to the ferric iron in a process known as reduction.

Normally, a plant will reduce and absorb only as much iron as it needs for its own well-being. But in cooperative studies in 1988 with Thomas LaRue at the Boyce Thompson Institute at Ithaca, New York, plant physiologist Ross M. Welch encountered a mutant pea plant that "couldn't say no" to iron and, if left unchecked, would continue to reduce and absorb iron until it accumulated toxic levels and died.

"We were looking for a way to increase iron in plants' edible parts and make the plants more nutritious to humans, so this particular plant really interested us," says Welch, who works at ARS' U.S. Plant, Soil, and Nutrition Laboratory at Ithaca. "We needed to understand how this plant absorbed so much iron."

Welch and fellow ARS scientists Leon V. Kochian and Wendell A. Norvell soon noticed another idiosyncrasy of the mutant pea plant. Not only was it a glutton for iron; it also accumulated unusually high (but not deadly) levels of copper, magnesium, manganese, zinc, and even potassium from soil containing typical levels of these elements.

"Yet the only difference we'd seen between the mutant pea plant and normal pea plants was that in the mutant, the ferric-chelate reductase was always turned on," Welch recalls. "That's when we began to think this reductase wasn't just for iron—that somehow plants used it to control the uptake of all nutrient metals."

KEITH WELLER

Turn-on: Ferric-chelate reductase makes nutrient solutions with pea roots change color—the darker the red, the greater the activity. Plant physiologist Ross Welch (right) and research assistant Jazier Romera from the University of Córdoba, Spain, evaluate changes under a range of plant nutrient deficiencies. (K5318-1)

To test their hypothesis, Welch, Kochian, and Norvell grew laboratory plants in such a way that various of them were deficient in either copper, iron, magnesium, zinc, or manganese.

When deficient in any of these nutrients, the plants responded by increasing their uptake of *all* available nutrient metals—not just iron. Magnesium-deficient plants turned on their ferric-chelate reductase, recalls Welch, even though magnesium itself cannot be reduced by the reductase.

"For example, the iron-deficient plants would reduce copper like crazy," he notes. "It didn't matter if the plants were deficient in manganese or magnesium, or even in zinc; they'd all reduce copper, iron, or manganese."

The ARS scientists think the most important action is not necessarily what reductase does to iron, copper, or manganese, but what it might be doing to sulfur—specifically, sulfur in a protein that makes up the openings to microscopic channels in plant root cells' outer membrane.

"The chemical state of sulfur may be critical in opening and closing these channels," says Welch. "We believe that in the case of the mutant pea plant, since the plant can't turn off the ferric-chelate reductase, the gates stay open and elements like copper and manganese just keep coming into root cells through those channels.

"We're the first to propose that one component of the nutrient transport process into cells is ferric-chelate reductase acting on the membrane, causing these channels to open and close."

If, in fact, gates in the cell membrane are opened in response to a shortage of one element, it would seem that an otherwise normal plant would be seriously at risk of overdosing on other elements it already contained in full measure.

But while the reductase may open nutrient transport channels, other factors, such as naturally occurring electrical signals in the cell membrane, might

be involved in closing these channels. Also, other transport proteins known as efflux pumps might be important in maintaining nutrient balance.

"Efflux pumps are tiny proteins embedded in the plant root cells' outer membranes," says Welch. "One end of the protein is on the interior surface of the membrane, but the protein extends through to the outside of the membrane.

"We know these efflux pumps exist for calcium. The hypothesis is that the protein can bind to calcium inside the root cell, transport it across the cell membrane, and pump it out of the cell. So when there's too much calcium inside the cell, the efflux pumps take the excess and pass it out."

Notably, the mutant pea plants that absorbed abnormally high levels of copper, zinc, manganese, and magnesium along with their iron overdose contained relatively normal levels of calcium. Welch says this indicates some mechanism such as calcium efflux pumps was working to prevent calcium overload.

In an experiment, the ARS researchers grew several of the iron-hungry mutant pea plants in a solution containing very high levels of 17 nutrients, including calcium and iron. Since the mutant plants have proved capable of overdosing on iron—even when grown on soil containing ordinary levels of the element—it seemed likely that they would face a rapid demise on the high-iron mixture.

For comparison, the scientists grew other mutant pea plants in another nutrient solution containing the same 17 nutrients, but at only one-quarter of the elevated levels.

Predictably, mortality was high...but only among the plants growing on the quarter-strength nutrient solution!

"The plants grown in the high concentrations of nutrients did take up excessive amounts of iron, compared to a normal plant, but not enough to kill themselves," Welch reports.

"We think that when the plants were faced with the very high calcium content of the higher nutrient concentration, the root cells' calcium efflux pumps went to work and pumped out the excess calcium—as well as enough of the iron and other nutrients—so that the plants couldn't overdose on iron.

"But in the quarter-strength nutrient solution, where the calcium concentration was low, there wasn't enough to stimulate the efflux pumps. Therefore the excess iron that the plants absorbed stayed in the cells and ultimately killed the plants."

KEITH WELLER

Mineral deficiency: A magnesium shortfall caused the chlorotic leaves and underdeveloped roots in the stunted pea plant. (K5319-1)

Still, Unsolved Mysteries

Some aspects of the ARS team's discoveries aren't as easy to understand. For example, Welch, Kochian, and Norvell were the first to show that plant root cells will reduce copper, although other studies had shown that the so-called "iron reductase" in yeast could reduce copper.

"But we don't know why the plant would need to reduce copper," Welch points out. "The plant can already absorb it in the oxidized cupric form found in soil, but we found it reduced copper to the cuprous form anyway."

Although the ARS researchers' interest in ferric-chelate reductase is based on a desire to improve plants as a source of iron, Welch says increased understanding of the reductases that affect root cells' outer membranes could have other benefits for agriculture.

"If we're right about reductases having a larger role in nutrient uptake, and you wanted a plant that would be very efficient at growing in nutrient-poor soils, you might just screen for plants with more reductase activity that could absorb more from the soil," he says.

"Or perhaps you needed a plant that could grow well on heavy-metal-contaminated soils—soils with too much copper, for example. In that case, you could select a plant with a low level of reductase.

"You could breed plants to have more or less reductase activity. We think Nature has already screened the plants in a sense; maybe the ones that grow where there's a lot of iron available in the soil are the ones that have evolved with lower reductase activity.

"There's still a lot to learn. For example, we don't know what controls ferric-chelate reductase activity, although research by Francisco J. Romera and colleagues at the University of Córdoba, Spain, has shown that if you apply substances that make ethylene in plant roots, it turns on the ferric-chelate reductase. We have to understand the mechanism for uptake before we can change it."—By **Sandy Miller Hays,** ARS.

Ross M. Welch is at the USDA-ARS U.S. Plant, Soil, and Nutrition Laboratory, Tower Road, Ithaca, NY 14853; phone (607) 255-5434, fax (607) 255-2459. ◆

Constructed Wetlands Clean Up

They could be an inexpensive, low-tech cure for farm pollution headaches.

The same tall grasses that thrive in wetlands throughout the world could prevent pollution of water resources by dairy farms.

"Scientists studying wetlands are finding these areas perform a great ecological service. They're nature's way of protecting water quality by filtering out nutrients, organic chemicals, heavy metals, and sediment from inflowing waters," says Charlie Cooper, ARS ecologist at the USDA National Sedimentation Laboratory in Oxford, Mississippi.

Since 1990, Cooper, along with ecologist Scott Knight and biologist Sam Testa, has been evaluating three manmade wetlands built on the Allan Scott farm near Herando, Mississippi.

Cooper says, "Constructed wetlands offer several benefits. They're energy efficient, relatively inexpensive to build, simple to operate, aesthetically pleasing, and they attract a variety of wildlife."

He adds, "Using wetlands to treat wastewater is not a new concept. Natural wetlands do an excellent job of processing contaminants, and cities have used them for years to treat municipal and some industrial wastewater."

On the 117-cow Scott dairy farm, a 135- by 170- by 8-foot-deep earthen settling lagoon receives wastewater collected from cleaning milking equipment, barn washings, runoff from the loafing (pre-milking) area, and rainfall.

"The lagoon's purpose," Knight explains, "is to settle out most of the solid contaminants."

Just below the lagoon, three 20- by 80- by 3-foot-deep earthen wetland cells were built to further treat the runoff pumped from the lagoon to a holding tank, from which a constant flow moves to the three parallel cells.

Says Knight, "We planted giant bulrushes, *Scripus validus,* at 1-foot intervals in the cells. Their purpose was to provide substrate for microorganisms that process or remove contaminants such as nitrogen, phosphorus, ammonia, and total suspended solids."

The team has been monitoring 18 water-quality indicators bi-weekly since May 1991, when the treatment system began working. They include levels of chlorophyll, several forms of phosphorus and nitrogen, as well as oxygen.

Two months after evaluation began, they built a fourth cell to further treat outflow from cell 1 to see what effect the additional treatment would have.

SCOTT BAUER

Clean water act: Giant bulrushes in these constructed wetlands provide a home for microorganisms that remove contaminants from a dairy farm's wastewater. (K5204-6)

"Adding this cell in series cuts in half the amounts of contaminants—like dissolved solids and phosphorus—that could be discharged from the system," Testa says.

The system is now entering its third year of operation. It has already proved very effective in removing two of the primary targets of the project—ammonia and coliform bacteria.

Each cell processes 51 cubic feet of wastewater a day, reducing the ammonia level by about 91 percent and coliform bacteria by 96 percent.

"That doesn't mean you can drink the water," Knight says, "but it is a major step toward reaching non-point contamination goals. These cells have no discharge more than half of the time, and a hay meadow below the cells retains runoff and nutrients when discharge does occur."

The constructed wetland project is part of the joint Demonstration Erosion Control Project in the Yazoo Basin involving ARS and the USDA Soil Conservation Service (SCS) in Jackson, Mississippi, the Vicksburg District of the U.S. Army Corps of Engineers, and the U.S. Army Engineers Waterways Experiment Station of the Corps.

SCS, the cooperating partner, designed and constructed the lagoon and wetland cells, while ARS is evaluating the project's efficiency in cleaning up wastewater.

Cooper, Knight, and Testa expect to continue monitoring the system and to develop operational and maintenance procedures for anyone planning to install it.—By **Hank Becker,** ARS.

Charlie Cooper, Scott Knight, and Sam Testa are in the USDA-ARS Water Quality/Ecology Research Unit, National Sedimentation Laboratory, P.O. Box 1157, Oxford, MS 38655; phone (601) 232-2935, fax (601) 232-2915. ◆

Science Update

Early Cotton Can Escape Late Insects, Storms

The less time a cotton crop is in the field, the less the risk and cost of bad weather and insect damage. Now breeders can get a new ARS early-season cotton that's ready about mid-July, 18 to 20 weeks after planting. An unusual bonus: Yields of the new line equal or exceed those of long-season varieties harvested 2 or more weeks later. The new plants also are completely hairless, making them less rewarding to insect pests hunting for secure spots to lay eggs. ARS released the new line, called C21S781-2, in cooperation with Rio Farms, Inc., and Texas A&M Agricultural Experiment Station. *Charles Cook, USDA-ARS Subtropical Agricultural Research Laboratory, Weslaco, Texas; phone (210) 969-4812.*

Outdoor Bait Evicts Pharaoh Ants

Pharaoh ants—indoor pests of hospitals, eateries, offices, apartments, and other buildings—often forage outdoors for food. This habit might be turned into a fatal weakness, allowing less use of pesticides inside buildings. Along the outside walls of an apartment building, ARS scientists placed commercial bait stations with a slow-acting pesticide. Within a week, the building's ant numbers dropped 90 percent. *David H. Oi and David F. Williams, USDA-ARS Medical and Veterinary Entomology Research Laboratory, Gainesville, Florida; phone (904) 374-5946.*

ARS To Place Nursery Crop Team at University Site

Two ARS researchers will join with Tennessee State University to develop anthracnose-resistant dogwoods and other landscape trees and shrubs that are hardy and attractive and need less pesticide. ARS' nursery crops research unit at TSU's new Nursery Crops Research Station in McMinnville will be among the first USDA research programs installed on the campus of an 1890 land-grant college or university. Construction of the TSU station—in a nationally important nursery-crop area—is set to begin in January 1994. The ARS/TSU team also will develop better ways to propagate, manage, and market nursery crops. *Howard J. Brooks, USDA-ARS associate deputy administrator for plant sciences, Beltsville, Maryland; phone (301) 504-6252. Bill Butt, director, Tennessee State University Nursery Crops Research Station, McMinnville, Tennessee; phone (615) 668-3023.*

Maine Yew Bush: Alternative Taxol Source?

Taxol, approved by the Food and Drug Administration for treating ovarian cancer, could be obtained from Maine's yew bushes. Research by ARS scientists showed that Maine yew bush needles have five times more taxol than the bark of the average western yew tree. The trees must be destroyed to yield the only current pharmaceutical taxol, but the Maine yew produces new needles each year. *James Duke, USDA-ARS National Germplasm Resources Laboratory, Beltsville, Maryland; phone (301) 504-5419.*

Fungus Stops Sesbania Weed

A natural fungus, *Colletotrichum truncatum,* can control hemp sesbania, among the most common weeds of southern soybean, cotton, and rice. In field tests, spraying fungi mixed with oil droplets in water killed more than 90 percent of the weed—comparable to commercial herbicide. ARS is patenting use of the fungus, and the scientists are developing ways to mass-produce it. *C. Douglas Boyette, USDA-ARS Southern Weed Science Laboratory, Stoneville, Mississippi; phone (601) 686-5217.*

Experimental Foot-and-Mouth Vaccine Passes First Test

Built from gene-engineered bacteria, a new experimental vaccine for foot-and-mouth disease may lead to stronger protection for U.S. livestock. In preliminary tests, the vaccine—the bacterially produced empty shell of the virus—prevented infection of guinea pigs and swine. Foot-and-mouth virus can infect cattle, sheep, and other cloven-hoofed animals, causing severe losses. It occurs in many foreign countries, so an improved vaccine would cut the risk of potential outbreaks in this country. *Marvin J. Grubman, USDA-ARS Plum Island Animal Disease Center, Greenport, New York; phone (516) 323-2500.*

Chinese Soybean Has Anti-Flood Genes

Though missing from commercial varieties, genes for flood tolerance have been found to exist in soybeans from backyard gardens in China. An ARS scientist is close to locating the genes, which let the "backyard soybeans" survive China's 1990 flood—its worst of the century. A gene map would help breeders develop flood-hardy soybeans for growers in this country. *Tara T. Van Toai, USDA-ARS Soil Drainage Research, Columbus, Ohio; phone (614) 292-9806.*

ARS Releases Florico, New Tropical Forage

Florico, a nutritious new stargrass forage, is well adapted to most of Florida and to other warm tropical areas. Grazing Florico in a rotation system, steers gained a pound a day. Developed by ARS and Agricultural Experiment Stations in Florida and Puerto Rico, Florico is vegetatively propagated and is available through Florida Foundation Seed Producers. *Mimi J. Williams, USDA-ARS Subtropical Agricultural Research Station, Brooksville, Florida; phone (904) 796-3385.*

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Upcoming in the JANUARY Issue

- ARS expertise helps rescue a Brazilian town from a fire ant population explosion.
- Scientists have located a gene that has broad implications in improving corn and other crop plants.
- Crimson clover disappearing from your field? Look for dark-winged fungus gnats.